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MATHEMATICS APPLIED TO DOMESTIC ARTS.

BY KATHARINE F. BALL.

A diligent search in mathematics textbooks that offer even the slightest promise of the application of mathematics to domestic arts, reveals how little attempt has been made to discover the part that mathematics plays in what has come to be considered peculiarly "woman's sphere." This is not because the domestic arts do not offer an opportunity for the application of mathematics, but because of general social and educational conditions that have affected the kind of training given to girls.

During the past few years scattering problems on foods and dress-making have crept into some of the so-called practical arithmetics and algebras, but there has been little attempt to gather such problems together into a systematic course for girls.

That is what we have been trying to do in our course in household mathematics in the Plainfield high school. The aim of this course is twofold: first, to emphasize the economic aspect of household problems, and, second, to make the girls skillful in solving the problems of the home. These two aims have determined the character of the course, the order of topics, and the mathematical content. We have tried to select only problems similar to those that actually occur in the home.

These problems have been grouped, not according to their mathematical content, but according to subject matter, the order of topics depending to some extent upon the order of topics in the home arts course, to some extent upon the difficulty of the problems, and to some extent upon the maturity of the girls. Under our present arrangement the course is allowed 7 credits, of which 5 are given in the sophomore year and 2 in the senior year.

In the sophomore year the course begins with a study of the budget system as applied to household management. This lays a foundation for the economic aspect of all the later work. The girls learn what a budget represents, how to plan a family budget, and how to apply the theory to their own personal expenditures. They are taught to keep a petty cash account, to distribute the items of expenditure under the budget headings, and to see that they keep within the budget estimates.

The budget divisions in a sense form an outline for the rest of the course. If we accept Bruère's choice of headings, the subjects taken up may be grouped as follows: food, shelter, clothing, operation, and advancement. At present we study food, clothing, and operation during the sophomore year, and shelter and advancement during the senior year. Whether or not this is a desirable arrangement is irrelevant to our present discussion.

The senior course offers little in the way of new problems, though it may be novel to consider them women's problems. The girls make an intensive study of methods of keeping household accounts, and they study investments, methods of purchasing homes, building and loan associations, mortgages, life insurance. They compare the expense of owning a home, such as loss of interest on investment, taxes, depreciation, etc., with rent of similar property. The maturity of the seniors makes it possible to study all these problems from a more or less personal point of view.

In the sophomore course the problems peculiar to domestic arts find their place. After the preliminary study of the budget system already mentioned, the first problems to be considered are those in operation, because they present fewest difficulties. These problems are concerned chiefly with matters of fuel for heat and light. The girls read the various kinds of meters in the school. They find out the difference in the number of feet of gas used per hour in a Welsbach and in an open burner; the reason why it is cheaper to use a gas iron rather than an electric iron; the number of hours of use needed to make a gas iron pay for itself; they discover why one cannot afford to use the ordinary carbon electric light bulb instead of a tungsten or Mazda. All these problems, though extremely simple as far as mathematics are concerned, have a legitimate place in the course because of their importance to the housekeeper.

Closely connected with operation is the matter of house furnishing and the buying of supplies. All the variety of problems in this group will readily occur to any housekeeper's mind:

estimating the amount of material needed for floor coverings, wall paper, table and bed linen, curtains, etc. We give the girls a little practice in drawing to scale, and teach them how to draw floor plans and interpret architect's drawings. The economic aspect of the problems is emphasized wherever possible, both in studying the relation that the value of furnishings should bear to the value of the house, and also in pointing out the significance of even a small saving through canny methods of purchase. *E. g.*, kitchen soap purchased by the cake at 5 cents or in quantities at 4 cents means a possible saving of 25 per cent. If the same per cent. of saving could be realized on all purchases what would it amount to in an outlay of $400?

The problems in house furnishings involve only denominate numbers, percentage, and mensuration of rectilinear figures and the circle. The circle is needed for such a problem as this:

How much lace is needed to edge a circular lunch cloth one yard in diameter?

In the next division of the budget, clothing, are included all problems concerned with estimating the amount of material needed for garments, the allowance for hems, tucks, straight and bias ruffles, and the cost of the same. These problems involve only fractions, linear measure, and square root, but I can assure you that they are sufficiently puzzling for an ordinary high-school sophomore.

To illustrate: A tuck shortens the goods by double the width of the tuck. Problem: How many ¼-inch tucks are needed to shorten a skirt 3 inches? The skirt is to be 38 inches long, finished. How long must each breadth be cut to allow for a 3-inch hem and three ¼-inch tucks?

Again: A ruffle should measure 1½ times the length of the goods to which it is attached. Problem: A child's petticoat measures 1½ yards around the bottom, and is to be 16 inches long finished, with a 1-inch hem. How much material 30 inches wide is required? If it is trimmed with a ruffle 3 inches wide, finished, that has a ½-inch hem and three $\frac{1}{16}$ inch tucks, how much will be needed for the ruffles? Will any extra material be needed for the band? At 35 cents a yard, how much will the petticoat cost?

Bias ruffles add a new difficulty. For the benefit of the men may I explain that a "true bias" is in reality the diagonal of a square whose side is the width of the goods. A bias strip is made by cutting parallel to the diagonal. The width of a bias strip is the perpendicular distance between the lines of cutting.

To estimate the length of a bias strip the dressmaker's rule is: multiply the width of the goods by $1\frac{1}{3}$ (approximately $\sqrt{2}$). In order to use this rule intelligently the girls learn how to find the square root of numbers, and how to make approximations.

Problem: Find the amount of material 20 inches wide, required for a 4-inch bias ruffle for a skirt 2 yards around the bottom, no strip to be less than 26 inches long. How much material will be wasted if the end pieces cannot be used? How much material would be needed for a straight ruffle?

If the material costs $1.15 a yard, how much less will the straight ruffle cost?

When the subject of food is taken up, the problems become more complex, although the arithmetic involved is simple enough. The terminology has already been mastered in other courses; the girls know about the composition of food and its fuel value, they know what a great Calorie means as applied to foods, they know what is meant by a "balanced ration." But before this knowledge can be of real service they need to have a great deal of practice in applying the principles of nutrition to the housewife's problem of planning correct dietaries readily and economically.

To apply the principles of nutrition necessitates the use of tables that give the composition and fuel value of foodstuffs. Of the tables that are available, those compiled by Atwater and published as a government bulletin are the most important as well as the cheapest.

The Atwater tables give both the composition of foodstuffs in per cent., and also the total number of Calories per pound.

To familiarize the girls with the use of these tables they are given problems like the following, and they are required to tabulate their results in a convenient form for future use.

I. Find the total number of Calories and the number of Calories of protein, fat, and carbohydrates in 1 cup of rice.

1 cup of rice equals 8 oz.
Rice contains 8 per cent. protein
1 oz. of protein yields 113 calories

The problem thus reduces to simple multiplication of the factors 8 oz., 8 per cent., and 113 Calories. To find the number of Calories of fat the method is the same, except that fat yields 255 Calories to the ounce.

Problems in the comparison of foods are also given.

E. g., how many ounces of sirloin steak will yield as many Calories of protein as one egg?

In such problems, the algebraic equation simplifies the solution, letting x represent the number of ounces of steak needed.

It is evident that the use of these tables involves more computation than is practicable for the average housekeeper. The information given is not in a form that makes it readily available for her use. What the housekeeper needs to know is not the number of Calories per pound, but per cup or ounce, not the chemical composition of foods in percentages, but the number of Calories of protein, fat, and carbohydrates per cup or ounce.

There are two other tables, either of which is more useful to the housekeeper than Atwater's; the table compiled by Professor Irving Fisher and reprinted as a bulletin by the American School of Home Economics, and the table compiled by Carlotta Greer and published in her "Textbook of Cooking." Both of these tables give the necessary information in a form that makes it readily available for the housewife's needs. Other admirable tables are those compiled by Locke, by Kinne and Cooley, and by Rose. But they are not so well adapted to use in the high school.* While tables in which the gram is used as the unit involve simpler computations, they are not practicable because the ounce and the cup are the housewife's measures. In a short high-school course, it is useless to suppose that the girls can be taught to think in grams. Both Fisher and Carlotta Greer use the ounce as the unit, and both base their calculations upon the hundred calorie portion. Instead of the per cent. of composition, as in Atwater, or the weight of each of the digestible nutrients, both the Fisher and the Greer tables state the number of Calories yielded by protein while Fisher adds also the number of Calories of fats and of carbohydrates. From either Fisher's or Greer's tables it is comparatively simple to compute the number of Calories of any given food stuff, and of a few standard recipes such as rice pudding, white sauce, etc. When the recipe is not found in the tables, its fuel value has to be computed from its respective ingredients, and then it is sometimes necessary to know how to use the Atwater tables.

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* Since this article was written a new food table admirably adapted to use in the high school has been published by Professor Mary S. Rose in her "Feeding the Family."

Although the actual mathematical principles involved in these computations are simple enough, it requires a great deal of practice to enable the girls to use the tables with any degree of skill.

They have to learn how to obtain approximate results, for approximations are really of more use to the housekeeper than the scientifically accurate results of the laboratory. In every way we try to simplify the methods of computation and to eliminate all but the essentials. Two main requirements only are considered in regard to dietaries: First, a sufficient total number of Calories, and second, the relatively correct number of protein Calories, thus assuming that if the per cent. of protein in the dietary is correct, the per cent. of fats and of carbohydrates can safely be left to adjust themselves. If the dietary needs correction because it is not balanced, the corrections are made entirely by trial.

The girls are expected to learn, both by practice and by actual memorization, the fuel value of certain common foods, *e. g.,* an egg, a slice of bread, a potato, a pat of butter, etc.; to know which foods can be used to increase or to decrease the per cent. of protein in a dietary; to know a certain list of combinations of foods that are practically balanced, *e. g.,* vegetable salads, bread and butter, etc. They are encouraged to make rough estimates of the fuel values of foods, recipes and dietaries, verifying their judgments by reference to the tables.

When the girls are sufficiently familiar with these fundamental principles and methods of dietetics, they have to consider also the economic aspect of the subject. Foods are then classified according to their cost per 100 Calories at the current local prices. The girls plan dietaries at a given cost per day, and learn how to lower the cost of living by choosing foods from the list of those that cost "less than 1 cent per 100 Calories." They find out which is the cheaper source of fuel at the current prices, eggs or steak, and they discover why tomatoes are a luxury as far as fuel value is concerned.

In all of this work we barely touch upon many of the important phases of dietetics: the ash constituent, the digestibility of food, the varying capacity of the different proteins for rebuilding tissue and sustaining life. All these, and many other complexities, have to be left for later and more intensive study in college. The aim of this part of the course has been achieved if the girls can use the tables readily, if they realize that it is not only desirable, but practicable for a housewife to plan meals scientifically, and if they are able to put their knowledge to use in planning balanced dietaries that have sufficient nourishment and variety and yet are within a specified cost.

This work in foods completes the sophomore course. An attempt has been made, by taking up the five divisions of the budget in the sophomore and the senior years, to include all types of household problems that involve mathematics in their solution. This course is still in the experimental stage, but the value of such training for the girls in the home arts course has been clearly demonstrated.

Plainfield High School,
Plainfield, N. J.